

INDOOR AIR QUALITY ASSESSMENT

**Pakachoag Elementary School
110 Pakachoag Street
Auburn, Massachusetts**



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Principal Peter Silverman and a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Pakachoag Elementary School, 110 Pakachoag Street, Auburn, Massachusetts. General concerns about poor indoor air quality prompted this request.

On January 30, 2001, a visit was made to the school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Mr. Silverman during the assessment.

The school consists of two wings. The original building is a brick exterior two-story building constructed in 1928. A third floor was added to the original building in 1956. A second two-story brick exterior wing was added to the south wall of the first building in 1961. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school has a student population of 310 and a staff of approximately 40. The tests were taken during normal operations at the school. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twenty of twenty-six areas surveyed, indicating an overall ventilation problem in the school. Classrooms have fresh air supplied by a unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of its case ([see Figure 1](#)). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were deactivated in several classrooms. Obstructions to airflow, such as boxes and tables blocking univents were seen in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must remain free of obstructions.

The building appears to have two different types of exhaust ventilation systems. The 1928 wing appears to have a gravity exhaust system, which uses rising heated air and a vent/chimney to remove air from classrooms (see Picture 1). Airflow into these vents is controlled by a louver system within the duct. Minimal airflow was detected in these vents and many were obstructed with a variety of materials (see Pictures 2 and 2A). The exhaust vents are located in the lower wall of coat closets in classrooms. Classroom air is drawn through a space beneath the closet door. This design allows for these vents to be easily blocked by stored materials. In a number of classrooms vents were blocked with books, book bags, boxes and other obstructions.

The 1961 wing uses motorized exhaust vents to eject air drawn from classrooms through wall-mounted air ducts. Exhaust vents in several classrooms did not appear to be drawing air indicating that several exhaust vent motors were likely inoperable and/or in need of repair (see Picture 3).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur,

leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 71° F to 76° F, which were within the BEHA recommended comfort guidelines in all areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building without a functioning ventilation system.

The relative humidity was measured in a range of 25 to 35 percent. This range is below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter months. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several classrooms had a number of plants (see Picture 4). Plant soil and drip pans can serve as source of mold growth. A number of these plants did not have drip pans or were in outdoor type planters with no drainage. The lack of drip pans and drainage can lead to water pooling and mold growth on windowsills when used indoors. Wooden sills can be potentially colonized by mold growth and serve as a source of mold odor. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Several classrooms have sinks that have a seam between the countertop and wall (see Picture 5). Water penetration through this seam can result if not watertight. Water penetration and chronic exposure to wood and plywood can cause these materials to swell and serve as a growth medium for mold.

Excessive water damage to brickwork was noted on the south exterior wall of the building. Over time, rainwater can work its way into mortar and brickwork causing cracks and fissures, which can lead to water penetration. Pooling water was noted on the cantilever roof over the exterior door (see Picture 6). Note that this roof is pitched *towards* the exterior wall, and has no support beneath it. The added weight of the water can increase tension, pulling the structure away from the building, and ultimately damaging the brickwork. Missing and/or damaged brickwork compromises the integrity of the building envelope and can provide a means of egress for moisture into the building.

Other Concerns

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The teacher's workroom contained five photocopiers. Photocopiers can produce VOCs and ozone, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No mechanical exhaust ventilation is provided in this area. Without mechanical exhaust ventilation, excess heat, odors and pollutants produced by office equipment can build up and lead to indoor air quality complaints.

Filters installed in univents provide minimal respirable dust filtration. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the univent through increased resistance (called pressure drop). Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

Student art projects constructed of milk cartons and pretzels were stored in classrooms and hallways (see Picture 7). A significant accumulation of stored soft drink

cans was noted in the teachers lounge (see Picture 8). Food and their containers may have residue that can serve to attract pests (e.g., mice and cockroaches). The use of these materials in art projects should be avoided to prevent the necessity for use of pesticides to rid the building of infestations.

The art room had a strong odor of laundry detergent. Open containers of laundry detergent were noted in the classroom and appeared to be used in art projects. Laundry detergent can contain fragrances and other materials that can be irritating to the eyes, nose and throat in some sensitive individuals.

Also of note was the amount of materials stored inside classrooms (see Picture 9). In classrooms throughout the school, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean around these areas. Dust can be irritating to the eyes, nose and respiratory tract. Materials should be relocated and/or cleaned periodically to avoid excessive dust build up.

Open holes around utility pipes (see Picture 10) and doors that open into the wall cavities (see Picture 11 and 11A) were noted in walls in the basement. Open pipes and utility holes as well as into wall cavities can provide a means of egress for odors, fumes, dusts and vapors from the storage space into classrooms.

Missing and ajar ceiling tiles, as well as spaces and holes in the interior walls of classrooms were also observed. Since wall cavities are unconditioned space and would be expected to have a lower temperature than heated classrooms, drafts of air moving

from the wall interiors into the classroom may occur. Particulates can move with airflow from the interior of the wall cavity into the classroom.

Conclusions/Recommendations

The conditions found at the Pakachoag Elementary School require a series of remedial steps. For this reason a two-phase approach is required, consisting of immediate (**short-term**) measures to improve air quality within the school and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns within the building.

In view of the findings at the time of this visit, the following **short-term** recommendations are made:

1. Remove all blockages from univents and exhaust vents.
2. Repair inoperable univents where feasible.
3. Repair inoperable exhaust vents.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
6. Consider installing local exhaust ventilation in teacher's room to operate during photocopying activities to remove excess heat and odors.
7. Remove food products and boxes to prevent the attraction of pests from classrooms.
8. Render holes in walls around utility pipes with an appropriate sealant compound.
9. Consider increasing the dust spot efficiency of univent filters.
10. Repair water damage to sink counter tops. Seal the counter/backsplash seam with a waterproof sealing compound.
11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
12. Replace all missing ceiling tiles.

The following **long-term** measures should be considered:

1. Examine the feasibility of providing better drainage for the roof shown in Picture 6.
2. Consideration should be given to replace univents if parts cannot be obtained.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1



Gravity Exhaust Vent Used for Storage

Picture 2



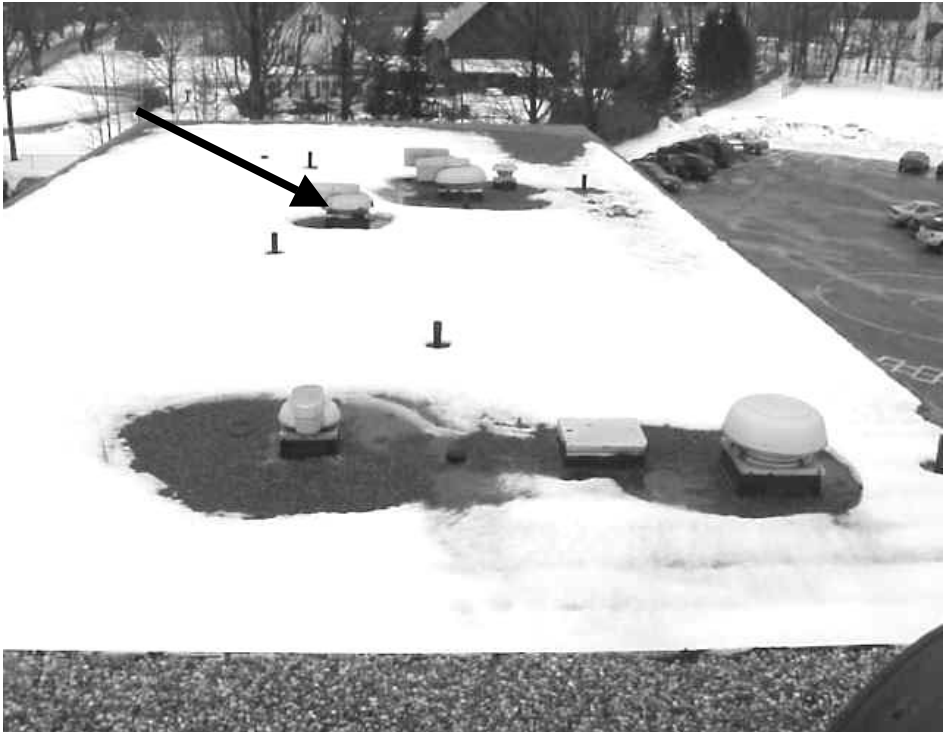
Closet Exhaust Vent Blocked in Closet

Picture 2A



Blocked Exhaust Vent, Note Pull Chain That Controls the Vent Louver System

Picture 3



Rooftop Exhaust Vent Motors

Picture 4



Flowering Plants In Classroom

Picture 5



Sink/Backsplash Seam That Can Be Subject to Water Damage

Picture 6



Cantilever Roof on South Wall, Note Water Stain on Exterior Wall

Picture 7



Pretzel/Milk Carton Art Project In Classroom

Picture 8



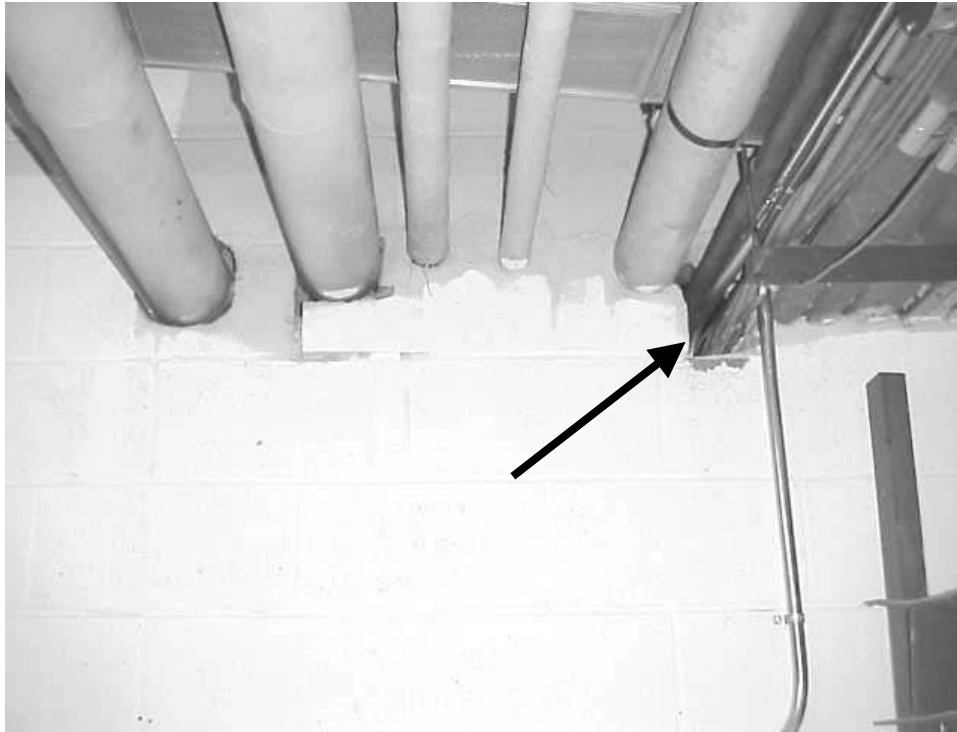
Accumulated Soft Drink Containers in Closet

Picture 9



Accumulated Materials Stored in Classroom Blocking Univent

Picture 10



Utility Conduits/Pipes Penetrating Wall, Note Unsealed Hole

Picture 11



Door Into Wall Cavity

Picture 11A



Inside Of Wall Cavity Behind Door in Picture 11

TABLE 1

Indoor Air Test Results – Pakachoag Elementary School, Auburn, MA – January 30, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	393	49	53					
Cafeteria	1865	71	35	150+	Yes	Yes	Yes	Univent motor burnt out
Room 4	1211	73	34	21	Yes	Yes	Yes	Exhaust off, univent completely blocked (picture), water bubbler-good sink
Room 3	1217	73	33	21	Yes	Yes	Yes	Exhaust off, water bubbler, restroom-exhaust on
Room 1	1287	73	34	24	Yes	Yes	Yes	Exhaust off, water bubbler
Room 2	1188	73	33	22	Yes	Yes	Yes	Univent blocked by table, exhaust off, water bubbler-sink, restroom-exhaust off, window open
Boy's Restroom						No	Yes	
Room V	602	75	34	22	Yes	Yes	Yes	Univent off, plants
Room VI	1175	74	31	22	Yes	Yes	Yes	Univent off-blocked by table, exhaust blocked by boxes, clutter, door open

* ppm = parts per million parts of air
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results – Pakachoag Elementary School, Auburn, MA – January 30, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Boy's Restroom							Yes	Plaster-old
Room VIII	1547	76	33	22	Yes	Yes	Yes	Univent off-blocked by paper, clutter, water damaged CT (2)/windowsill, door open
Room VII	1372	74	32	23	Yes	Yes	Yes	Univent off, exhaust blocked by boxes, clutter, door open
Office	1081	74	30	1	Yes	Yes	No	Univent off, window mounted A/C, 1 water damaged CT, door open
Music Room	1423	74	32	23	Yes	Yes	Yes	Window and door open, univent off, 1 water damaged CT
Room IV-A	746	72	30	2	Yes	No	No	Window open
Room IV-B	575	72	29	5	Yes	Yes	Yes	Window open
Room III	873	74	29	0	Yes	Yes	No	Door open
Room III-A	1057	76	30	1	Yes	No	Yes	Door open
Work Room	890	75	29	2	No	No	No	Photocopiers-odor, 1 lamination machine

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TABLE 3

Indoor Air Test Results – Pakachoag Elementary School, Auburn, MA – January 30, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Library	785	72	26	0	No	No	No	Door open
Computer Room	707	74	25	0	No	No	No	
Art Room	1688	73	35	14	No	No	No	Laundry detergent odor
Reading Room Annex	1044	73	28	5	No	No	No	Space to boiler room
Room 10	875	71	31	22	Yes	Yes	Yes	Univent blocked by table, clutter
Teacher's Lounge	1188	73	30	2	Yes	No	No	Toaster, accumulated cans
Room 6	820	76	30	19	Yes	Yes	Yes	Exhaust off, white board
Room 9	810	76	31	19	Yes	Yes	Yes	Exhaust off, cans, food, lysol
Room 8	624	74	28	21	Yes	Yes	Yes	Exhaust off, space around sink, door open
Room 5	624	74	30	3	Yes	Yes	Yes	Exhaust off, window and door open

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